REMARKS

In view of the above amendments and following remarks, reexamination and reconsideration are respectfully requested.

By this Amendment, claims 1-11 have been amended, and claims 12-23 have been newly added. Accordingly, it is submitted that claims 1-23 are currently pending in this application.

Further by this Amendment, the Applicants have reviewed and revised the Specification and Abstract so as to make minor editorial amendments. Enclosed herewith is a substitute Abstract. Moreover, enclosed herewith is a marked-up version of the Specification, Abstract, and Claims entitled ***"Version with Markings to Show Changes Made"*** which reflects the changes made therein. The Applicants submit that no new matter has been added.

It is noted that the Examiner has rejected claims 1-10 under 35 U.S.C. § 112, second paragraph, for the reason contained on page 2 of the Office Action. Particularly, the Examiner has taken the position that the limitations directed towards the separating means in claim 1 is unclear.

It is further noted with appreciation that the Examiner has indicated, on page 3 of the Office Action, that each of claims 1-10 contain allowable subject matter and would be allowed if amended to overcome the aforementioned rejection under 35 U.S.C. § 112, second paragraph.

Accordingly, by this Amendment, independent claim 1 has been amended so as to clarify the limitations pertaining to the separating means so as to ensure compliance with 35 U.S.C. § 112, second paragraph. Accordingly, it is submitted that each of claims 1-10 satisfies the requirements of 35 U.S.C. § 112, second paragraph. Moreover, it is submitted that each of claims 1-10 are now allowable.

Next, it is noted that the Examiner has rejected claim 11 under 35 U.S.C. § 102(b) as being anticipated by Kitamura et al. (JP 11-135862) for the reason contained on pages 2-3 of the Office Action.

Without intending to acquiesce to the Examiner's aforementioned prior art rejection, the Applicants have amended claim 11 so as to incorporate the allowable subject matter indicated by the Examiner on page 3 in connection with claims 1-10. Particularly, claim 11 has been amended so as

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to recite that the method comprises "*supplying the input optical signal to a light emitting device for transmitting the input optical signal, and emitting, based on the transmitted input optical signal, a dummy optical signal having a waveform obtained by inverting a waveform of the input optical signal....*"

Accordingly, it is submitted that claim 11 is allowable for at least the reasons mentioned in the Examiner's reasons for allowance contained on page 3 of the Office Action.

Next, it is noted that the Applicants have added new claims 12-21 which generally correspond to each of claims 1-10 but which, unlike claims 1-10, have been drafted so as not to be interpreted as means-plus-function type claims under 35 U.S.C. § 112, sixth paragraph. It is submitted that each of claims 12-21 are allowable for at least the same reasons as claims 1-10, respectively.

Further by this Amendment, the Applicants have added new dependent claims 22-23.

For at least the foregoing reasons, it is submitted that each of claims 1-23 clearly are allowable.

Accordingly, it is submitted that the present application now in fact clearly is in condition for allowance and the Examiner therefore is requested to pass this case to issue.

In the event, however that the Examiner has any comments or suggestions of a nature necessary to place this case in condition for allowance, then **the Examiner is kindly requested to contact Applicants' undersigned attorney by telephone to promptly resolve any such matters.**

Respectfully submitted,

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Version with Markings to Show Changes Made

1. (Amended) An optical amplifying device for amplifying an input optical signal, said device comprising:

a light-emitting means for transmitting the [said] input optical signal and emitting, based on the [said] optical signal transmitted by said light-emitting means, a dummy optical signal having a waveform obtained by inverting a waveform of the [said] input optical signal and having a wavelength that is different from a wavelength of the [said] input optical signal;

a control means for controlling the wavelength of the [said] dummy optical signal emitted from said light-emitting means;

an amplifying means for amplifying the [said] optical signal and the [said] dummy optical signal transmitted from said light-emitting means , and outputting an amplified optical signal; and

a separating means for separating the [said] input optical signal from the amplified [an] optical signal outputted by said amplifying means [after amplification].

2. (Amended) The optical amplifying device according to claim 1, wherein [¶] the [said] dummy optical signal is equal in amplitude to the [said] input optical signal.

3. (Amended) The optical amplifying device according to claim 1, wherein [¶] said control means controls the wavelength and an amplitude of the [said] dummy optical signal emitted from said light-emitting means.

4. (Amended) The optical amplifying device according to claim 1, wherein [¶] said separating means separates the [said] input optical signal and the [said] dummy optical signal individually.

5. (Amended) The optical amplifying device according to claim 4, wherein [¶] said control means carries out feedback control of said light-emitting means based on the dummy optical signal separated by said separating means.

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6. (Amended) The optical amplifying device according to claim 4, wherein [¶] said control means controls the wavelength and an amplitude of the [said] dummy optical signal emitted from said light-emitting means, and carries out feedback control of said light-emitting means based on the dummy optical signal separated by said separating means.

7. (Amended) The optical amplifying device according to claim 1, wherein [¶] said separating means collectively separates the [said] input optical signal and the [said] dummy optical signal.

8. (Amended) The optical amplifying device according to claim 7, wherein [¶] said separating means is an optical router with an AWG (Arrayed Wave Guide) structure.

9. (Amended) The optical amplifying device according to claim 1, wherein [¶] said light-emitting means is a distributed Bragg reflector (DBR) type semiconductor laser.

10. (Amended) The optical amplifying device according to claim 1, wherein [¶] the [said] input optical signal is a burst optical signal.

11. (Amended) An optical amplifying method for amplifying an input optical signal, said method comprising [the steps of]:

supplying the input optical signal to a light emitting device for transmitting the [said] input optical signal, and emitting, based on the [said] transmitted input optical signal, a dummy optical signal having a waveform obtained by inverting a waveform of the [said] input optical signal and having a wavelength that is different from a wavelength of the [said] input optical signal;

collectively amplifying the [said transmitted] input optical signal and the [said emitted] dummy optical signal transmitted from the light emitting device, and outputting an amplified optical signal; and

separating the [said] input optical signal from the amplified [an] optical signal [after amplification].

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TITLE OF THE INVENTION

OPTICAL AMPLIFYING DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to optical amplifying devices for amplifying an input optical signal and, more specifically, to an optical amplifying device suitable for use in amplifying a burst optical signal.

Description of the Background Art

[0002] As well known, when intermittently-inputted optical signals (hereinafter referred to as burst optical signals) are amplified through a general optical fiber amplifier, for example, waveform degradation, called optical surges, occurs in the optical signals. Optical surges are now briefly described with reference to the accompanying drawings.

[0003] Optical surges are caused by transient response of optical amplifiers. How much the input optical signal is degraded in a waveform depends on the characteristics of the optical amplifier, such as a relaxation time constant. Waveform degradation also depends on the input optical signal itself. As the input light varies in power, the waveform becomes degraded.

[0004] FIG. 18a shows the waveform of an optical signal when the amount of data traffic is small and data is intermittently

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transmitted, such as a case where data packets are spaced long. If such burst optical signal as shown in FIG. 18a is provided to an optical amplifier, temporary periods during which no data is provided at all are observed, which are hereinafter referred to as a no-data period. If an optical signal is provided after a long no-data period, input light optical power varies. Therefore, as shown in FIG. 18b, the optical signal after amplification is instantaneously increased in level (optical surges), thereby causing degradation in the waveform.

[0005] Such waveform degradation in a transmission system makes it difficult for a receiving side to always optimally identify data. Thus, optical surges have to be suppressed. From this viewpoint, one optical amplifying device capable of carrying out optical amplification while suppressing optical surges is disclosed in Japanese Patent Laid-Open Publication No. 11-135862 (1999-135862). This conventional optical amplifying device (hereinafter referred to as conventional device) is described below with reference to the drawings.

[0006] As shown in FIG. 19, a conventional device 9000 is provided with an input optical signal of a wavelength $\lambda 1$ as shown in FIG. 20a. The provided optical signal is branched into two by an optical brancher 910. One branched optical signal goes through an optical receiver 920, an inverting amplifier 940, and a light source 924, thereby being converted into an optical signal of a wavelength λd with its logic level inverted, as shown in

FIG. 20b. Then, the converted optical signal is multiplexed with the other optical signal branched by the optical brancher 910. The optical signal after such multiplexing is constant in optical power, as shown in FIG. 20c.

[0007] The optical signal after multiplexing is amplified by an optical fiber amplifier 916. At this time, optical surges do not occur since the input light is constant in optical power. The amplified optical signal is provided to an optical filter 918, wherein the optical signal of the wavelength λ1 is passed through.

[0008] As such, according to the conventional device 9000, the input optical signal is superposed with a dummy optical signal having a different ~~differed in~~ wavelength. Thus, the input light provided to the amplifier 916 can become temporarily constant in optical power. In this way, optical amplification can be carried while optical surges are suppressed.

[0009] As stated above, in the conventional device, the input optical signal is superposed with the dummy optical signal, and then provided to the amplifier. Therefore, the optical signal provided to the amplifier becomes larger in optical power on average than the input optical signal. In general, amplification gain of the amplifier varies according to the average optical power of the optical signal provided to the amplifier. The larger the optical power of the input light is, the less the amplification gain is. Therefore, in the conventional device, the amplification gain of the amplifier is disadvantageouly reduced.

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semiconductor laser 432, a controller 434, the optical amplifier 116, and the optical filter 118. Note that, in FIG. 9, components identical in structure to those shown in FIG. 1 are provided with the same reference numerals. With reference to FIGS. 9, 10a, and 10b, the operation of the optical amplifying device according to the present embodiment is now described.

[0058] The optical amplifying device 4000 is provided with an input optical signal having a waveform $\lambda 1$. This optical signal carries burst-like binary digital data. FIG. 10a shows the waveform of this optical signal.

[0059] The semiconductor laser 432 is controlled by the controller 434 so as to produce an optical signal having a wavelength λd and identical in amplitude of the received optical signal having the wavelength $\lambda 1$. The semiconductor laser 432 is implemented as a distributed Bragg reflector (DBR) type semiconductor laser, for example. Such a semiconductor laser has characteristics of, when an optical signal having a wavelength different from that of the semiconductor laser is externally provided thereto, suppressing oscillation thereof and transmitting this externally-provided optical signal.

[0060] In other words, while the input light with wavelength $\lambda 1$ to the semiconductor laser 432 is 0 in optical power, that is, while the optical power is 0 during both of the data and no-data periods shown in FIG. 10a, the semiconductor laser ~~423~~ 432 produces an optical signal of predetermined power having a wavelength

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λd under the control of the controller 434. On the other hand, while the input light to the semiconductor laser 432 is not 0 in optical power, the semiconductor laser 432 is suppressed in oscillation in response to the optical power. Therefore, the waveform of the optical signal having the wavelength λd outputted from the semiconductor laser 432 becomes the inverted one of the input light, as shown in FIG. 10b. This optical signal of the wavelength λd corresponds to the dummy optical signal in the above-described conventional device and optical amplifying device according to the first embodiment.

[0061] From the semiconductor laser 432, the light of the wavelength $\lambda 1$ transmitted therethrough and the above-stated dummy optical signal of the wavelength λd are both outputted. As stated above, the light and the dummy optical signal are inverted in waveform to each other. Therefore, the light outputted from the semiconductor laser 432 is constant in optical power.

[0062] The light outputted from the semiconductor laser 432 is amplified by the optical amplifier 116. At this time, the light provided to the optical amplifier 116 is approximately constant in optical power, and therefore optical surges do not occur. After amplification, the optical filter 118 passes the optical signal of the wavelength $\lambda 1$.

[0063] As described above, in the fourth embodiment, the optical signal of the wavelength $\lambda 1$ to be amplified is provided

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wavelength $\lambda 1$. Similarly, if optical signals with different wavelengths $\lambda 1$ to λn are provided in a time-division manner, for example, these optical signals can be amplified without degradation in waveform. In this case, however, the wavelength λd of the dummy optical signal has to be different from any of the wavelengths $\lambda 1$ to λn.

[0074] In the present embodiment, the first optical router 536 has two output ports. Alternatively, the first optical router 536 may have three or more output ports for outputting lights of the wavelengths $\lambda 1$ to λn and λd.

[0075] Here, consider a case where the optical amplifying device 5000 according to the present embodiment is used to construct a system as shown in FIG. 14. If a distance L1 between the optical amplifying device 5000 and a first optical receiver 30 is different from'a distance L2 between the optical amplifying device 5000 and a second optical receiver 32, optical signals of wavelengths $\lambda 1$ and λd both outputted from the optical amplifying device 5000 are disadvantageously ~~differed~~ different in transmission characteristic (S/N ratio), even though they are identical in amplitude.

[0076] To get around the above problem, if the distance L1 is longer than the distance L2, the controller 434 controls the dummy optical signal of the wavelength λd outputted from the semiconductor laser 432 to be smaller in amplitude than the optical signal of the wavelength $\lambda 1$ to be amplified. Thus, the

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to the optical signal of the wavelength λ1 to be amplified.

[0079] In general, semiconductor lasers are feedback-controlled based on ~~an output~~ light output therefrom. However, in the present embodiment, the output light from the semiconductor laser 432 includes the light of the wavelength λ1 and the dummy optical signal of the wavelength λd, and therefore cannot be referred to for feedback control. For this reason, in the present embodiment, the first optical router 536 separates the controller 434 with the optical signal of the wavelength λd from the amplified optical signal for feedback control.

[0080] As described above, according to the present embodiment, the optical signal of the wavelength λd outputted from the first optical router 536 is monitored. Thus, in addition to the effects similar to those in the fourth embodiment, the optical amplifying device according to the fifth embodiment has ~~such~~ an effect ~~as~~ such that the output light from the semiconductor laser 432 can be controlled more accurately.

[0081] With reference to FIGS. 16, 17a, and 17b, described is a system in which an optical signal is amplified by an optical amplifying device and then again amplified for long-distance transmission

[0082] (Seventh Embodiment)

FIG. 16 is a block diagram showing the structure of an optical transmission system according to a seventh embodiment of the present invention. The optical transmission system includes

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an optical amplifying device 7000, second optical amplifiers 40a and 40b, and optical filters 50a and 50b. The optical amplifying device 7000 includes semiconductor lasers 732a and 732b, controllers 734a and 734b, an optical multiplexer 738, the first optical amplifier 116, and a second optical router 736. Note that the first optical amplifier 116 shown in FIG. 16 is identical in structure to the optical amplifier 116 shown in FIG. 11. The operation of the present optical transmission system is now described below.

[0083] The optical amplifying device 7000 is provided with two optical signals having different wavelengths, one with a wavelength λ1 and the other with a wavelength λ2. The optical signal of the wavelength λ1 is provided to the semiconductor laser 732a, which is controlled by the controller 734a, and then multiplexed with a dummy optical signal of a wavelength λd1. On the other hand, the optical signal of the wavelength λ2 is provided to the semiconductor laser 732b, which is controlled by the controller 734b, and then multiplexed with a dummy optical signal of a wavelength of λd2.

[0084] Output lights from the semiconductor lasers 732a and 732b are multiplexed with each other by the optical multiplexer 738, and then amplified by the first optical amplifier 116. At this time, the output lights from the semiconductor lasers 732a and 732b are constant in optical power and, accordingly, an output light from the optical multiplexer 738 is also constant in optical

power. Therefore, optical surges at optical amplification do not occur in the first optical amplifier 116.

[0085] The amplified optical signal is provided to the second optical router 736. The second optical router 736 has first and second output ports, and is structured as an AWG (Arrayed Wave Guide) having cyclic transmittance characteristics as shown in FIG. 17a. Of the input optical signal having a spectrum shown in FIG. 17b, the second optical router 736 outputs, from the first output port, the optical signal of the wavelength $\lambda 1$ to be amplified and the dummy optical signal of the wavelength $\lambda d1$ and, from the second output port, the optical signal of the wavelength $\lambda 2$ to be amplified and the dummy optical signal of the wavelength $\lambda d2$.

[0086] The optical signal outputted from the first output port is again amplified by the second optical amplifier 40a in the course of transmission through an optical fiber. The optical signal inputted to the second optical amplifier 40a is constant in optical power, like the output light from the semiconductor laser 732a. Therefore, optical surges at optical amplification do not occur in the second optical ampiifier 40a. The amplified optical signal is provided to the optical filter 50a that passes the optical signal of the wavelength $\lambda 1$.

[0087] Similarly, the optical signal outputted from the second output port is again amplified by the second optical amplifier 40b, and then provided to the optical filter 50b that

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ABSTRACT OF THE DISCLOSURE

An optical brancher ~~110~~ branches an input optical signal into two. An optical detector ~~120~~ converts one optical signal branched by the optical brancher ~~110~~ into an electrical signal. A first controller ~~122~~ generates a control electrical signal having a waveform obtained by inverting the envelope of the electrical signal. Based on the control electrical signal, an optical signal generator ~~124~~ produces a dummy optical signal having a waveform λd and an amplitude $\alpha/2$. The other signal branched by the optical brancher ~~110~~ is delayed by a delay unit ~~112~~ for a predetermined time, and then multiplexed by an optical multiplexer ~~114~~ with the dummy optical signal from the optical signal generator ~~124~~. An optical amplifier ~~116~~ amplifies a multiplexed optical signal. An optical filter ~~118~~ separates an optical signal of a wavelength $\lambda 1$ from the amplified optical signal. Thus, optical signal amplification can be carried out without optical surges.

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